#### **Afterword**



# **No Turning Back**

As shown by the human experiences and ecological changes described in this book, the Yellowstone fires of 1988 were both an event that occurred at a specific time in social and natural history, and part of an ongoing process. Areas that burned are sometimes referred to as having returned to a "biological starting point," but it is not the same point from which they started after the last fire, any more than we can go back to looking at fire in Yellowstone as we did before 1988.

Although large fires have occurred in the area for millennia, Yellowstone's history is not simply one of repeated cycles. Instead of returning the park to some past primeval state, the 1988 fires used the materials at hand to shape the park's future. The ecological processes that have formed the Yellowstone landscape in the past will continue to do so, but in different proportions, on different scales, and at different rates than in the past. What patterns emerge will depend on the pre-fire patterns in the landscape, the patterns left in 1988 by variations in fire type and severity, and post-fire conditions such as climate. Wildland areas are not destined to achieve some particular ideal state if we could remove the human influences. We can look back, but never turn back. If the trend toward a warmer, drier climate in Yellowstone continues, the abundance and distribution of plant and animal species will shift, and large fires may occur more frequently.

Just as the human presence in and around wildlands is inescapable, so is human intervention necessary to preserve wildlands. But interventions that diminish wilderness values should be pursued only when human communities are clearly threatened. It is disturbing when nature shows its muscle with more zeal than we would like: it seems that we want nature, but don't want it to be completely natural; we want it to behave in a civilized manner. The question is whether Yellowstone, a public trust, should be a stage where nature is allowed to perform, making up the script as it goes along. But if this is not possible in Yellowstone, then where?





### Chapter 1: The Role of Fire in Yellowstone

- 1. Despain, D. 1990. Yellowstone vegetation, consequences of environment and history in a natural setting. Roberts Rinehart, Boulder, Colorado. 238 pages.
- Barrett, S.W. 1994. Fire regimes on andesitic mountain terrain in northeastern Yellowstone National Park. International Journal of Wildland Fire 4(2):65-76.
- 3. Houston, D.B. 1982. The northern Yellowstone elk. MacMillan, New York. 474 pages.
- 4. Balling, R.C., Meyer, G.A., and S.G. Wells. 1992a. Climate change in Yellowstone National Park: is the drought-related risk of wildfires increasing? Climatic Change 22:35-45
- 5. Romme, W. H., and D.G. Despain. 1989. Historical perspective on the Yellowstone fires of 1988. Bioscience 39(10): 695-699.
- Meyer, G.A., and S.G. Wells. 1997. Fire-related sedimentation events on alluvial fans, Yellowstone National Park. Journal of Sedimentary Research A67(5): 776-791.
- 7. Millspaugh, S.H., C. Whitlock, and P. Bartlein. 2000. Variations in fire frequency and climate over the past 17,000 yr in central Yellowstone National Park. Geology (28)3:211-214.
- 8. Balling et al., Climate change in Yellowstone.
- 9. Morrison, M. 1993. Fire in paradise: the Yellowstone fires and the politics of environmentalism. Harper Collins Publishers, Inc., New York. 253 pages.
- 10. Houston, D.B. 1983. Wildfires in Yellowstone National Park. Ecology 54(5):1111-1117.
- 11. Pyne, S.J. 1989. Letting wild fire loose: the fires of '88. Montana, The Magazine of Western Living 39(3): 76-79.
- 12. Renkin, R., and D. Despain. 1992. Fuel moisture, forest type and lightning-caused fire in Yellowstone National Park. Canadian Journal of Forest Research 22 (1):37-45.
- 13. Despain, Yellowstone vegetation.
- 14. Renkin and Despain, Fuel moisture.
- 15. Ibid.
- 16. Ibid.
- 17. Balling, R.C., Meyer, G.A., and S.G. Wells. 1992b.

- Relation of surface climate and burned area in Yellowstone National Park. Agricultural and Forest Meteorology 60(3-4): 285-293.
- 18. Renkin and Despain, Fuel moisture.
- Brown, J.K 1991. Should management ignitions be used in Yellowstone National Park? Pages 137-148 in R.B. Keiter and M. Boyce, eds. The Greater Yellowstone Ecosystem: redefining America's wilderness heritage. Yale University Press, New Haven, Connecticut.
- 20. Brown, J.K. 1989. Could the 1988 fires in Yellowstone have been avoided through prescribed burning? Fire Management Notes 50(4): 7-13.
- 21. Schullery, P., and D.G. Despain. 1989. Prescribed burning in Yellowstone National Park: a doubtful proposition. Western Wildlands 15(2):30-34.
- 22. Chase, A. 1988. How Yellowstone got burned. Outside. 13 (12): 33, 35-36.
- 23. Christensen, N.L., J.K. Agee, P.F. Brussard, J. Hughes, D.H. Knight, G.W. Minshall, J.M. Peek, S.J. Pyne, F.J. Swanson, J.W. Thomas, S. Wells, S.E. Williams, and H.A. Wright. 1989. Ecological consequences of the 1988 fires in the Greater Yellowstone Area. The Greater Yellowstone Postfire Ecological Assessment Workshop Final Report. 58 pages.

### Chapter 2: The Summer of 1988

- 1. Varley, J.D. and P. Schullery. 1991. Reality and opportunity in the Yellowstone fires of 1988. Pages 105-122 in R.B. Keiter and M. Boyce, eds. The Greater Yellowstone Ecosystem: redefining America's wilderness heritage. Yale University Press, New Haven, Connecticut.
- Collins, Katharine. 1988. Experts predict park fies will slow down. Casper Star Tribune, Casper, Wyoming. August 5, 1988.
- Neckels, J., B. Mutch, R. Wallace, B. Van Zee, and E. Waldapfel. 1988. Greater Yellowstone Area fire situation 1988. Greater Yellowstone Coordinating Committee. 207 pages.
- Mills, S., ed. 1989. The Greater Yellowstone postfire assessment. Greater Yellowstone Coordinating Committee. 147 pages.
- 5. Neckels et al., Greater Yellowstone Area fire situation.
- 6. Rothermel, R.C., R.A. Hartford, and C.H. Chase. 1994. Fire growth maps for the 1988 Greater Yellow-

- stone Area fires. USFS General Technical Report INT-304. 64 pages. Rothermel et al., Fire growth maps.
- Despain, D.G., A.R. Rodman, P. Schullery, and H.F. Shovic. 1989. Burned area survey of Yellowstone National Park. Geographic Information Systems Laboratory, Yellowstone National Park. 14 pages.
- 8. Ibid
- 9. Varley and Schullery, Reality and opportunity.
- 10. Romme, W. H., and D.G. Despain. 1989. Historical perspective on the Yellowstone fires of 1988. BioScience 39(10): 695-699.
- Schullery, P., and D.G. Despain. 1989. Prescribed burning in Yellowstone National Park: a doubtful proposition. Western Wildlands 15(2):30-34.
- 12. Romme and Despain, Historical perspective.
- 13. Morrison, M. 1993. Fire in paradise: the Yellowstone fires and the politics of environmentalism. Harper Collins Publishers, Inc., New York. 253 pages.
- 14. Ibid.
- 15. Neckels et al., Greater Yellowstone Area fire situation.
- 16. Morrison, Fire in paradise.
- 17. Mills, Yellowstone postfire assessment.
- 18. Brown, J.K. 1989. Could the 1988 fires in Yellowstone have been avoided through prescribed burning? Fire Management Notes 50(4): 7-13.
- 19. Mills, Yellowstone postfire assessment.
- Greenberg, M.R., Sachsman, D.B. Sandman, P.M., and K.L. Salomone. 1989. Risk, drama and geography in coverage of environmental risk by network TV. Journalism Quarterly 66(2): 267-276.
- 21. Morrison, Fire in paradise.
- 22. Smith, C. 1996. Media coverage of fire ecology in Yellowstone after 1988. Pages 25-34 *in* J. Greenlee, ed. The ecological implications of fire in Greater Yellowstone: proceedings of the second biennial conference on the Greater Yellowstone Ecosystem. International Association of Wildland Fire, Fairfield, Washington.
- 23. Smith, Media coverage of fire ecology.

#### Chapter 3: The Human Aftermath

 Mills, S., ed. 1989. The Greater Yellowstone postfire assessment. Greater Yellowstone Coordinating Committee. 147 pages. See also: Christensen, N.L., J.K. Agee, P.F. Brussard, J. Hughes, D.H. Knight, G.W. Minshall, J.M. Peek, S.J. Pyne, F.J. Swanson, J.W. Tho-

- mas, S. Wells, S.E. Williams, and H.A. Wright. 1989. Ecological consequences of the 1988 fires in the Greater Yellowstone Area. The Greater Yellowstone Postfire Ecological Assessment Workshop Final Rept. 58 pages.
- 2. Comstock, Theo. B. 1874. The Yellowstone National Park: its scientific value. American Naturalist 8:65-79.
- 3. Mills, Yellowstone postfire assessment.
- 4. Williams, E.D., and S.C. Smith. 1990. Rehabilitation of fire suppression impacts on the North Fork fire in Yellowstone National Park. Report to the U.S. Department of the Interior. YNP/LA 90-01.
- 5. Ibid.
- 6. Ibid.
- 7. Johnson, A.M., and KA. Lippincott. 1989. Post-fire archeological assessment. Yellowstone National Park. Manuscript on file.
- 8. Ibid.
- 9. Connor, M.A., and K.P. Cannon. 1991. Forest fires as a site formation process in the Rocky Mountains of northwestern Wyoming. Archaeology in Montana 32(2):1-14.
- 10. Cannon, K.P., and P. Phillips. 1993. Post-fire inventory and evaluation in Yellowstone National Park: the 1989 field season. Midwest Archeological Center Technical Report No. 24.
- 11. Connor, M.A., K.P. Cannon, and D. Carlevato. 1989. The mountain burnt: forest fires and site formation processes. North American Archaeologist 10: 293-310.
- 12. Johnson, A.M., S.W. Conner, and K.J. Feyl. 1991. Post-fire identification of nineteenth century wooden structures. Archaeology in Montana 32(2): 33-47.
- 13. Cannon and Phillips, Post-fire inventory.
- 14. Polzin, P.E., M.S. Yuan, and E.G. Schuster. 1993. Some economic impacts of the 1988 fires in the Yellowstone area. U.S. Department of Agriculture, Forest Service. Research Note INT-418.
- 15. Snepenger, D.J., J.D. Johnson, and N. Friede. 1996. Tourism in Montana after the 1988 fires in Yellowstone National Park. Pages 23-24 in J. Greenlee, ed. The ecological implications of fire in Greater Yellowstone: proceedings of the second biennial conference on the Greater Yellowstone Ecosystem. International Association of Wildland Fire, Fairfield, Washington.
- Pyne, S.J. 1989. Burning questions and false alarms about wildfires at Yellowstone. Forum for Applied Research and Public Policy 4(2): 31-40.

- 17. Bath, A.J. 1993. Attitudes toward fire and fire management issues in Yellowstone National Park. Ph.D. diss., University of Calgary, Alberta, Canada.
- Fire Management Policy Review Team. 1989. Final report on fire management policy. U.S. Department of Interior, Fish & Wildlife Service, Washington, D.C.
- 19. Bonnicksen, T.M. 1989. Fire gods and federal policy. American Forests 95(7/8): 14-16.

### Chapter 4: Changes in the Landscape

- Despain, D. 1990. Yellowstone vegetation, consequences of environment and history in a natural setting. Roberts Rinehart, Boulder, Colorado. 239 pages.
- Balling, R.C., Meyer, G.A., and S.G. Wells. 1992a. Climate change in Yellowstone National Park: is the drought-related risk of wildfires increasing? Climatic Change 22:35-45.
- 3. Romme, W.H., and D.H. Knight. 1982. Landscape diversity: the concept applied to Yellowstone Park. BioScience 32(8):664-669.
- 4. Houston, D.B. 1982. The northern Yellowstone elk. MacMillan, New York. 474 pages.
- 5. Romme and Knight, Landscape diversity.
- Turner, M.G., W. Hargrove, R.H. Gardner, and W.H. Romme. 1994a. Effects of fire on landscape heterogeneity in Yellowstone National Park. Journal of Vegetation Science 5:731-742.
- Ellis, M., C.D. von Dohlen, J.E. Anderson and W.H. Romme. 1994. Some important factors affecting density of lodgepole pine seedlings following the 1988 Yellowstone fires. Pages 139-150 in D. Despain, ed. Plants and their environments: proceedings of the first scientific conference on the Greater Yellowstone Ecosystem. NPS/NRYELL/NRTR. USDI, NPS, Denver.
- 8. Reed, R.A., M.E. Finley, W.H. Romme, and M.G. Turner. 1999. Aboveground net primary production and leaf-area index in early postfire vegetation in Yellowstone National Park. Ecosystems 2:88-94.
- 9. Taylor, D.L. 1973. Some ecological implications of forest fire control in Yellowstone National Park. Ecology 54(6):1394-1396.
- Meagher, M.M. and D. Houston. 1998. Yellowstone and the biology of time. University of Oklahoma Press, Norman, Oklahoma. 287 pages.
- 11. Mills, S., ed. 1989. The Greater Yellowstone postfire assessment. Greater Yellowstone Coordinating Committee. 147 pages.

- 12. Runnells, D.D., and M.A. Siders. 1991. Pages 149 to 155 *in* University of Wyoming National Park Service Research Center Annual Report.
- 13. Montagne, C., and E. Skogley. 1992. Burned-unburned resin extractor soil nutrient comparison. Final report from the Plant and Soil Science Department and the Montana Agricultural Experiment Station, Montana State University, Bozeman.
- 14. Ryan, K.C., and G.D. Amman. 1996. Bark beetle activity and delayed tree mortality in the Greater Yellowstone Area following the 1988 fires. Pages 151-158 in J. Greenlee, ed. The ecological implications of fire in Greater Yellowstone: proceedings of the second biennial conference on the Greater Yellowstone Ecosystem. International Association of Wildland Fire, Fairfield, Washington.
- 15. Knight, D.H. 1994. Mountains and plains: the ecology of Wyoming landscapes. Yale University Press, New Haven, Connecticut. 338 pages.
- Turner, M.G., W.H. Romme, R.H. Gardner, and W.W. Hargrove. 1997. Effects of fire size and pattern on early succession in Yellowstone National Park. Ecological Monographs 76(4):411-433.
- 17. Amman, G.D. and K..C. Ryan, K. C. 1991. Insect infestation of fire-injured trees in the Greater Yellowstone Area. USDA Forest Service, Intermountain Research Station, Ogden, Utah. Research Note INT-398.
- 18. Parker, D.L., and L.E. Stipe. 1993. A sequence of destruction: mountain pine beetle and wildfire. Technical Report, USDA Forest Service, Southwest Region.
- 19. Ryan and Amman, Bark beetle activity.
- 20. Ibid.
- 21. USDA Forest Service, Northern Region. 1998. Montana: forest insect and disease conditions and program highlights 1997. Report 98-2.
- 22. Despain, Yellowstone vegetation.
- 23. Johnson, E.A., and G.I. Fryer. 1989. Population dynamics in lodgepole pine-Engelmann spruce forests. Ecology 70:1335-1345.
- 24. Despain, D., R. Clark and J. Reardon. 1996. Effects of crown fire on the crown seed bank of lodgepole pine in Yellowstone National Park. Pages 15-19 *in* J. Greenlee, ed. The ecological implications of fire in Greater Yellowstone: proceedings of the second biennial conference on the Greater Yellowstone Ecosystem. International Assoc. of Wildland Fire, Fairfield, Washington.
- 25. Anderson, J.E., and W.H. Romme. 1991. Initial

- floristics in lodgepole pine forests following the 1988 Yellowstone fires. International Journal of Wildland Fire. 1:119-124.
- 26. Ellis et al., Some important factors affecting density of lodgepole pine seedlings.
- 27. Nyland, R.D. 1998. Patterns of lodgepole pine regeneration following the 1988 Yellowstone fires. Forest Ecology and Management 111(1):23-33.
- 28. Romme, W.H. 1999. Causes and consequences of alternative successional trajectories following the 1988 Yellowstone fires. Investigators' Annual Reports. Yellowstone National Park.
- 29. Personal communication, Burger, John, University of New Hampshire.
- 30. Turner et al., Effects of fire size on landscape.
- 31. Tomback. D.F. *In press.* Clark's nutcracker: agent of regeneration. *In* D.F. Tomback, ed. Whitebark pine communities: ecology and restoration. Island Press, Washington, D.C.
- 32. Kendall, K.C. 1998. Whitebark pine. Pages 483 to 485 *in* Mac, M.J., P.A. Opler, C.E. Puckette Haecker, and P.D. Doran, eds. Status and trends of the nation's biological resources. Vol. 2. U.S. Department of the Interior, U.S. Geological Survey, Reston, Virginia.
- 33. Ibid.
- 34. Ibid.
- 35. Tomback, D.F., A.J. Anderies, K.S. Carsey, and M.L. Powell. *In press*. Delayed seed germination in whitebark pine and regeneration patterns following the Yellowstone fires. Ecology.
- 36. Renkin, R., and D. Despain 1996. Preburn root biomass/basal area influences on the response of aspen to fire and herbivory. Pages 95-106 *in* J. Greenlee, ed. The ecological implications of fire in Greater Yellowstone: proceedings of the second biennial conference on the Greater Yellowstone Ecosystem. International Association of Wildland Fire, Fairfield, Washington.
- 37. Romme, W.H., M.G. Turner, L.L. Wallace, and J.S. Walker. 1995. Aspen, elk, and fire in northern Yellowstone National Park. Ecology 76(7):2097-2106.
- 38. Barmore, W. *In press.* Ecology of ungulates and their winter range in Yellowstone National Park. Yellowstone Center for Resources, Yellowstone National Park, Mammoth, Wyoming.
- 39. Despain, Yellowstone vegetation.
- 40. Renkin and Despain, Response of aspen to fire.

- 41. Meagher and Houston, The biology of time.
- 42. Kay, C.E, and F.H. Wagner. 1996. Response of shrubaspen to Yellowstone's 1988 wildfires; implications for "natural regulation" management. Pages 107-112 in J. Greenlee, ed. The ecological implications of fire in Greater Yellowstone: proceedings of the second biennial conference on the Greater Yellowstone Ecosystem. International Association of Wildland Fire, Fairfield, Washington.
- 43. White, C.A., C.E. Olmsted, and C.E. Kay. 1998. Aspen, elk, and fire in the Rocky Mountain national parks of North America. Wildlife Society Bulletin 26(3): 449-462
- 44. Renkin and Despain, Response of aspen to fire.
- 45. Ibid.
- 46. Ibid.
- 47. Romme et al., Aspen, elk, and fire.
- 48. Renkin and Despain, Response of aspen to fire.
- 49. Kay and Wagner, Response of shrub-aspen to Yellowstone's wildfires.
- 50. Kay, C.E. 1997. Ungulate herbivory, willows, and political ecology in Yellowstone. Journal of Range Management 50(2):139-145.
- 51. Romme, W.H., M.G. Turner. R.H. Gardner, W.W. Hargrove, G.A. Tuskan, D.G. Despain, and R.A. Renkin. 1997. A rare episode of sexual reproduction in aspen (*Populus tremuloides Michx.*) following the 1988 Yellowstone fires. Natural Areas Journal 17:17-25.
- 52. Ibid.
- 53. Renkin and Despain, Response of aspen to fire and herbivory.
- 54. Romme et al., Sexual reproduction in aspen.
- 55. Ripple, W.J., and E.J. Larsen. *In press.* The role of postfire coarse woody debris in aspen regeneration. Western Journal of Applied Forestry 16(2).
- 56. Renkin and Despain, Response of aspen to herbivory.
- 57. Turner et al., Effects of fire size.
- 58. Turner, M.G., R.A. Reed, W.H. Romme, M.E. Finley, and D.H. Knight. 1997. Above-ground net primary production, leaf area index, and nitrogen dynamics in early post-fire vegetation, Yellowstone National Park. Pages 130 to 134 *in* University of Wyoming National Park Service Research Center.
- 59. Tracy, B.F. 1997. Fire effects in Yellowstone's grasslands. Yellowstone Science 5(3): 2-5.

- 60. Meagher and Houston, The biology of time.
- 61. Knight, D.H., and L.L. Wallace. 1989. The Yellowstone fires: issues in landscape ecology. BioScience 39:707-715.
- 62. Tracy, B.F. and S.J. McNaughton. 1997. Elk grazing and vegetation responses following a late season fire in Yellowstone National Park. Plant Ecology 130 (2):111-119.
- 63. Merrill, E., and R. Marrs. 1997. Remote sensing of vegetation recovery in grasslands after the 1988 fires in Yellowstone National Park. Pages 130-133 in The University of Wyoming National Park Service Research Center Annual Report.
- 64. Tracy and McNaughton, Elk grazing and vegetation.
- 65. Meagher and Houston, The biology of time.
- 66. Tracy, Fire effects in Yellowstone's grasslands.
- 67. Yellowstone National Park. 1997. Yellowstone's northern range: complexity and change in a wildland ecosytem. National Park Service, Mammoth Hot Springs, Wyoming. 148 pages.
- 68. Engstrom, D.R., C. Whitlock, S.C. Fritz, and H.E. Wright, Jr. 1991. Recent environmental changes inferred from the sediments of small lakes in Yellowstone's northern range. Journal of Paleolimnology 5(2):139-174.
- 69. Meagher and Houston, The biology of time.
- 70. Singer, F.J., L.C. Mack, and R.C. Cates. 1994. Ungulate herbivory of willows on Yellowstone's northern winter range. Journal of Range Management 47:435-443.
- 71. Ibid. See also: Meagher and Houston, The biology of time.
- 72. Norland, J.E, F.J. Singer, and L. Mack. 1996. Effects of the Yellowstone fires of 1988 on elk habitats. Pages 223-232 *in* J. Greenlee, ed. The ecological implications of fire in Greater Yellowstone: proceedings of the second biennial conference on the Greater Yellowstone Ecosystem. International Association of Wildland Fire, Fairfield, Washington.
- 73. Tyers, D.B. Submitted Ph.D. diss. Winter ecology of moose on the northern Yellowstone range. Montana State University, Bozeman.
- 74. Norland et al., Effects of the Yellowstone fires on elk habitats.
- 75. Chadde, S. and C. Kay. 1991. Tall-willow communities on Yellowstone's northern range: a test of the "natural regulation" paradigm. Pages 231-262 *in* R.R. Keiter and M. Boyce, eds. The Greater Yellowstone Ecosystem: redefining America's wilderness heritage. Yale Uni-

- versity Press, New Haven, Connecticut.
- 76. Singer et al., Ungulate herbivory.
- 77. Singer, F.J., Zeigenfuss, L.C., Cates, R.G., and D.T. Barnett, D.T. 1998. Elk, multiple factors, and persistence of willows in national parks. Wildlife Society Bulletin 26(3):419-428.
- 78. Turner et al., Effects of fire size on landscape.

### Chapter 5: Wildlife

- 1. Singer, F.J., W. Schreier, J. Oppenheim, and E.O. Garton. 1989. Drought, fires, and large mammals. BioScience 39(10):716-722.
- French, M.G., and S. French. 1996. Large mammal mortality in the 1988 Yellowstone fires. Pages 113-115 in J. Greenlee, ed. The ecological implications of fire in Greater Yellowstone: proceedings of the second biennial conference on the Greater Yellowstone Ecosystem. International Association of Wildland Fire, Fairfield, Washington.
- 3. Singer et al, Drought, fires, and large mammals.
- Boyce, M. and E.H. Merrill. 1996. Predicting effects of 1988 fires on ungulates in Yellowstone National Park. Pages 361-68 in F.J. Singer, ed. Effects of grazing by wild ungulates in Yellowstone National Park. National Park Service, Natural Resource Information Division, Denver, Colorado.
- Singer, F.J., and P. Schullery. 1989. Yellowstone wildlife: populations in process. Western Wildlands 15 (2): 18-22.
- 6. Singer et al, Drought, fires, and large mammals.
- 7. Ibid.
- 8. Farnes, P., C. Heydon, and K. Hansen. 1999. Snowpack distribution across Yellowstone National Park. Final Report to Yellowstone National Park.
- 9. DelGuidice, G.D., and F.J. Singer. 1996. Physiological responses of Yellowstone elk to winter nutritional restriction before and after the 1988 fires: a preliminary examination. Pages 133-135 *in* J. Greenlee, ed. The ecological implications of fire in Greater Yellowstone: proceedings of the second biennial conference on the Greater Yellowstone Ecosystem. International Association of Wildland Fire, Fairfield, Washington.
- Turner, M.G., Y. Wu, L.L. Wallace, W.H. Romme, and A. Brenkert. 1994b. Simulating winter interactions among ungulates, vegetation, and fire in northern Yellowstone Park. Ecological Applications 4(3):472-496.

- 11. Wu, Y., M.G. Turner, L.L. Wallace, and W.H. Romme. 1996. Elk survival following the 1988 fires: a simulation experiment. Natural Areas Journal 16(3):198-207.
- 12. Coughenour, M.B. and F.J. Singer. 1996. Yellowstone elk population responses to fire—a comparison of land-scape carrying capacity and spatial-dynamic cosystem modeling approaches. Pages 169-179 in J. Greenlee, ed. The ecological implications of fire in Greater Yellowstone: proceedings of the second biennial conference on the Greater Yellowstone Ecosystem. International Assoc. of Wildland Fire, Fairfield, Washington.
- 13. Singer, F.J., A. Harting, K.K. Symonds, and M.B. Coughenour. 1997. Density dependence, compensation, and environmental effects on elk calf mortality in Yellowstone National Park. Journal of Wildlife Management 61(1):12-15.
- 14. Tracy, B.F., and S.J. McNaughton. 1997. Elk grazing and vegetation responses following a late season fire in Yellowstone National Park. Plant Ecology 130(2):111-119.
- 15. Tracy, B.F. 1998. Fire effects, elk, and ecosystem resilience in Yellowstone's sagebrush grasslands. Abstract in Yellowstone Science supplement 6(2):53.
- 16. Boyce and Merrill, Predicting effects of 1998 fires.
- 17. Wallace, L.L., M.G. Turner, W.H. Romme, R.V. O'Neill and Y. Wu. 1995. Scale of heterogeneity of forage production and winter foraging by elk and bison. Landscape Ecology. 10(2):75-83.
- 18. Pearson, S., M.G. Turner, L.L. Wallace, and W.H. Romme. 1995. Winter habitat use by large ungulates following fire in northern Yellowstone National Park. Ecological Applications 5(3):744-755.
- 19. Norland, J.E, F.J. Singer, and L. Mack. 1996. Effects of the Yellowstone fires of 1988 on elk habitats. Pages 223-232 *in* J. Greenlee, ed. The ecological implications of fire in Greater Yellowstone: proceedings of the second biennial conference on the Greater Yellowstone Ecosystem. International Association of Wildland Fire, Fairfield, Washington.
- 20. Vales, D.J., and J.M. Peek. 1996. Responses of elk to the 1988 Yellowstone fires and drought. Pages 159-167 *in* J. Greenlee, ed. The ecological implications of fire in Greater Yellowstone: proceedings of the second biennial conference on the Greater Yellowstone Ecosystem. International Association of Wildland Fire, Fairfield, Washington.
- 21. Singer, F.J. and M.K. Harter. 1996. Comparative effects of elk herbivory and 1988 fires on northern

- Yellowstone National Park grasslands. Ecological Applications 6(1):185-199.
- 22. Tracy and McNaughton, Elk grazing and vegetation responses.
- 23. Singer and Harter, Comparative effects of elk herbivory.
- 24. Van Dyke, F., M.J. Deboer, and G.M. Van Beek. 1996. Winter range plant production and elk use following prescribed burning. Pages 193-200 in J. Greenlee, ed. The ecological implications of fire in Greater Yellowstone: proceedings of the second biennial conference on the Greater Yellowstone Ecosystem. International Association of Wildland Fire, Fairfield, Washington.
- 25. White, P.J., and R.A. Garrott. 1993. Bark eating by Yellowstone elk. Yellowstone Science 1(4):2-5.
- 26. Vales and Peek, Responses of elk to the 1988 fires.
- Jakubas, W.J., R.A. Garrott, P.J. White, and D.R. Mertens. 1994. Fire-induced changes in the nutritional quality of lodgepole pine bark. Journal of Wildlife Management 58:35-46.
- 28. Lemke, T.O., J.A. Mack, and D.B. Houston. Winter range expansion by the northern Yellowstone elk herd. Intermountain Journal of Sciences 4(1/2): 1-9.
- 29. Scott, M.D., and H. Geisser. 1996. Pronghorn migration and habitat use following the 1988 Yellowstone fires. Pages 123-132 in J. Greenlee, ed. The ecological implications of fire in Greater Yellowstone: proceedings of the second biennial conference on the Greater Yellowstone Ecosystem. International Association of Wildland Fire, Fairfield, Washington.
- Houston, D.B. 1982. The northern Yellowstone elk. MacMillan, New York. See also: Schullery and Whittlesey, 1992.
- 31. Kelsall, J.P., E.S. Telfer, and T.D. Wright. 1977. The effects of fire on the ecology of the boreal forest, with particular reference to the Canadian north. Occasional paper 323. Canadian Wildlife Service, Ottawa. 58 pages. See also: Schwartz, C.C., and A.W. Franzmann. 1989. Bears, wolves, moose, and forest succession; some management considerations on the Kenai peninsula, Alaska. Alces 25:1-10.
- Gruell, G.E. 1980. Fire's influence on wildlife habitat on the Bridger-Teton National Forest, Wyoming. Intermountain Forest and Range Experiment Station, Ogden, Utah. USDA Research Paper INT-235.
- 33. Tyers, D.B. *Submitted Ph.D. diss.* Winter ecology of moose on the northern Yellowstone range. Montana State University, Bozeman.

- 34. Singer, F.J., W. Schreier, J. Oppenheim, and E.O. Garton. 1989. Drought, fires, and large mammals. BioScience 39(10):716-722
- 35. Blanchard, B.M., and R.R. Knight. 1990. Reactions of grizzly bears to wildfire in Yellowstone National Park. Canadian Field-Naturalist 104:592-594.
- 36. Blanchard, B.M., and R.R. Knight. 1996. Effects of wildfire on grizzly bear movements and food habits. Pages 117-122 *in* J. Greenlee, ed. The ecological implications of fire in Greater Yellowstone: proceedings of the second biennial conference on the Greater Yellowstone Ecosystem. International Association of Wildland Fire, Fairfield, Washington.
- 37. Podruzny, S.R., D.P. Reinhart, amd D.J. Mattson. *In press.* Fire, red squirrels, whitebark pine, and Yellowstone grizzly bears. Ecology.
- 38. Crabtree, R.L. and J.W. Sheldon. 1999. The ecological role of coyotes on Yellowstone's northern range. Yellowstone Science 7(2):15-23.
- 39. Renkin, R. 1989. Small mammal communities after the 1988 Yellowstone fires. Yellowstone National Park. Report on file.
- 40. Bissonette, J.A. and S.S. Sherburne. 1992. Habitat preferences of unexploited pine marten (*Martes americana*) populations in Yellowstone National Park. Final report. Utah Cooperative Fish and Wildlife Research Unit, Logan, Utah.
- 41. Ibid.
- 42. Taylor, D.L. 1982. Competition between mountain bluebirds and tree swallows in post-fire areas of Yellowstone National Park. National Geographic Society Research Reports 14: 655-667.
- 43. Gniadek, S. 1977. Some aspects of avian ecology following the 1974 Trail Creek and 1976 Divide fires in Yellowstone National Park. Final Research Report.
- 44. McEneaney, T. 1990. Yellowstone: not so black and white. The Living Bird Quarterly, Spring: 11-17.
- 45. Hutto, R.L. 1995. The composition of bird communities following stand-replacement fires in northern Rocky Mountain conifer forests. Conservation Biology 9:1041-1058.
- 46. Amman, G.D. and K..C. Ryan, K. C. 1991. Insect infestation of fire-injured trees in the Greater Yellowstone Area. USDA Forest Service, Intermountain Research Station, Ogden, Utah. Research Note INT-398.
- 47. Christiansen, T.A., and R.J. Lavigne. 1996. Habitat requirements for the reestablishment of litter inverte-

- brates following the 1988 Yellowstone National Park fires. Pages 147-150 *in* J. Greenlee, ed. The ecological implications of fire in Greater Yellowstone: proceedings of the second biennial conference on the Greater Yellowstone Ecosystem. International Association of Wildland Fire, Fairfield, Washington.
- 48. Christiansen, T. 1996. Terrestrial litter invertebrate communities in Yellowstone Park. Yellowstone Science 4(2): 2-3.
- 49. Beetle, D.E. 1997. Recolonization of burned aspen groves by land snails. Yellowstone Science 5(3):6-8.
- 50. Patla, D.A., and C.R. Peterson. 1994. The effects of habitat modification on a spotted frog population in Yellowstone National Park. Pages 135 to 144 in University of Wyoming National Park Service Research Center Annual Report.
- 51. Koch, E.D., and C.R. Peterson. 1995. Amphibians and reptiles of Yellowstone and Grand Teton National Park. University of Utah Press, Salt Lake City. 188 pages.

#### Chapter 6: Watershed and Stream Dynamics

- Minshall, G.W., and C.T. Robinson. 1993. Effects of the 1988 wildfires on stream systems of Yellowstone National Park: five-year comparison. University of Wyoming/National Park Service Research Center.
- Minshall, G.W., J.T. Brock, and J.D. Varley. 1989. Wildfires and Yellowstone's stream ecosystems. Bio-Science 39:707-715.
- Meyer, G.A., and S.G. Wells. 1997. Fire-related sedimentation events on alluvial fans, Yellowstone National Park. Journal of Sedimentary Research A67(5):776-791.
- 4. Minshall, G.W., J.T. Brock and T.V. Royer. 1998. Stream ecosystem responses to the 1988 wildfires. Yellowstone Science 6(3): 15-22.
- 5. Meyer and Wells, Fire-related sedimentation events.
- 6. Minshall et al., Stream ecosystem responses.
- 7. Farnes, P.E., W.W. McCaughey, and K.J. Hansen. *In press*. Role of fire in determining annual water yield in mountain watersheds. Chapter 11 *in* L. Wallace, ed. After the fires: the ecology of change in Yellowstone National Park. Yale University Press, New Haven, Connecticut.
- 8. McIntryre, M.J., and G.W. Minshall. 1996. Changes in transport and retention of coarse particulate organic matter in streams subject to fire. Pages 59-76 in J. Greenlee, ed. The ecological implications of fire in Greater Yellowstone: proceedings of the second bien-

- nial conference on the Greater Yellowstone Ecosystem. International Association of Wildland Fire, Fairfield, Washington.
- 9. Troendle, C.A., and G.S. Bevenger. 1996. Effect of fire on streamflow and sediment transport in Shoshone National Forest. Pages 43-52 *in* J. Greenlee, ed. The ecological implications of fire in Greater Yellowstone: proceedings of the second biennial conference on the Greater Yellowstone Ecosystem. International Association of Wildland Fire, Fairfield, Washington.
- U.S. Fish and Wildlife Service. 1993. Annual project technical report for 1992, fishery and aquatic management program, Yellowstone National Park.
- 11. Marston, R.A., and D.H. Haire. 1990. Runoff and soil loss following the 1988 Yellowstone fires. Great Plains-Rocky Mountain Geographical Journal. 18:1-8.
- 12. Varley, J.D., and P. Schullery. 2000. Yellowstone fishes: ecology, history, and angling in the park. Stackpole Books, Mechanicsburg, Pennsylvania.
- 13. Lawrence, D.E., and G.W. Minshall. 1994. Short- and long-term postfire changes in riparian zone vegetation and stream macroinvertebrate community structure. Pages 171-184 *in* D. Despain, ed. Plants and their environments: proceedings of the first scientific conference on the Greater Yellowstone Ecosystem. Technical Report NPS/NRYELL/NRTR. USDI, NPS, Denver, Colorado.
- Tinker, D.B., and D.H. Knight. 1998. Fire and the dynamics of coarse woody debris in Yellowstone National Park. Conference abstract in Yellowstone Science supplement 6(2):53.
- 15. McIntyre and Minshall, Changes in transport.
- 16. Minshall and Robinson, Effects of the 1988 wildfires.
- 17. Minshall et al., Wildfires and Yellowstone's streams.
- 18. Young, M.K. and M.A. Bozek. 1996. Post-fire effects on coarse woody debris and adult trout in northwestern Wyoming streams. Pages 147-150 *in* J. Greenlee, ed. The ecological implications of fire in Greater Yellowstone: proceedings of the second biennial conference on the Greater Yellowstone Ecosystem. International Assoc. of Wildland Fire, Fairfield, Washington.
- 19. Minshall et al., Stream ecosystem responses.
- 20. Ewing, R. 1996. Postfire suspended sediment from Yellowstone National Park, Wyoming. Journal of the American Water Resources Association 32(3):605-627.
- 21. Troendle and Bevenger, Effect of fire on streamflow.

- 22. Young and Bozek, Post-fire effects on woody debris.
- 23. Mahony, D.L., and R.E. Gresswell. 1998. Short-term postfire variation of physical habitat, fish populations, and associated aquatic communities in large streams of Yellowstone National Park. Conference abstract in Yellowstone Science supplement 6(2): 39.
- 24. Minshall and Robinson, Effects of the 1988 wildfires.
- 25. Ibid.
- 26. McIntyre and Minshall, Changes in transport.
- 27. Robinson, C.T., and G.W. Minshall. 1996. Physical and chemical responses of streams in Yellowstone National Park following the 1988 wildfires. Pages 217-222 in J. Greenlee, ed. The ecological implications of fire in Greater Yellowstone: proceedings of the second biennial conference on the Greater Yellowstone Ecosystem. International Association of Wildland Fire, Fairfield, Washington.
- 28. Minshall, G.W., and J.T. Brock. 1991. Observed and anticipated effect of forest fire on Yellowstone stream ecosystems. Pages 146-157 in R.R. Keiter and M. Boyce, eds. The Greater Yellowstone Ecosystem: redefining America's Wilderness Heritage. Yale University Press, New Haven, Connecticut.
- 29. Minshall et al., Wildfires and Yellowstone's streams.
- 30. Minshall and Robinson, Effects of the 1988 wildfires.
- 31. Lathrop, R.G. 1994. Impacts of the 1988 wildfires on the water quality of Yellowstone and Lewis Lakes, Wyoming. International Journal of Wildland Fire. 4(3):169-175.
- 32. U.S. Fish and Wildlife Service, 1993 annual report.
- 33. Minshall et al., Stream ecosystem responses.
- 34. Robinson and Minshall, Responses of streams.
- 35. Brass, J.A, V.G. Ambrosia, P.J.Riggan and P.D. Sebesta. 1996. Consequences of fire on aquatic nitrate and phosphate dynamics in Yellowstone National Park. Pages 53-58 *in* J. Greenlee, ed. The ecological implications of fire in Greater Yellowstone: proceedings of the second biennial conference on the Greater Yellowstone Ecosystem. International Association of Wildland Fire, Fairfield, Washington.
- Runnells, D.D., and M.A. Siders. 1991. Pages 149 to 155 in University of Wyoming National Park Service Research Center Annual Report.
- 37. \_\_\_\_\_, S.W. Rushforth, and G.W. Minshall. 1996. Diatom assemblages in Cache Creek, Yellowstone Na-

- tional Park. Pages 77-81 *in* J. Greenlee, ed. The ecological implications of fire in Greater Yellowstone: proceedings of the second biennial conference on the Greater Yellowstone Ecosystem. International Association of Wildland Fire, Fairfield, Washington.
- 38. Romme, W.H., and D.H. Knight. 1982. Landscape diversity: the concept applied to Yellowstone Park. BioScience 32(8):664-669.
- 39. Lathrop, Water quality of Yellowstone and Lewis Lakes.
- 40. Theriot, E.C., S.C. Fritz, and R.W. Gresswell. 1997. Long-term limnological data from the larger lakes of Yellowstone National Park. Arctic and Alpine Research 29(3):304-314.
- 41. Minshall et al., Stream ecosystem responses.
- 42. Mihuc, T.B., G.W. Minshall.and C.T. Robinson. 1996. Response of benthic macroinvertebrate propulations in Cache Creek, Yellowstone National Park to the 1988 wildfires. Pages 77-82 *in* J. Greenlee, ed. The ecological implications of fire in Greater Yellowstone: proceedings of the second biennial conference on the Greater Yellowstone Ecosystem. International Association of Wildland Fire, Fairfield, Washington.
- 43. Minshall et al., Stream ecosystem responses.
- 44. Mihuc, T.B. and G.W. Minshall. 1995. Trophic generalists vs. trophic specialists: implications for food web dynamics in post-fire streams. Ecology 76:2361-2372.
- 45. Minshall, G.W., C.T. Robinson, T.V. Royer, and S.R. Rushforth. 1995. Benthic community structure in two

- adjacent streams in Yellowstone National Park. Great Basin Naturalist 55(3): 193-200.
- 46. U.S. Fish and Wildlife Service, 1993 annual report.
- 47. Roemhild, G. 1994. Aquatic insects and the fires of 1988. Yellowstone Science 2(2):2-4.
- 48. Minshall et al., Stream ecosystem responses.
- 49. Young and Bozek, Post-fire effects on woody debris.
- 50. U.S. Fish and Wildlife Service, 1993 annual report.
- 51. Ibid.
- 52. Gresswell, R.E. 1996. Relative Effects of fire and anthropogenic perturbations on Yellowstone cutthroat trout in Yellowstone Lake. Page 17 in The ecological implications of fire in Greater Yellowstone, agenda & abstracts. Yellowstone National Park, Mammoth Hot Springs, Wyoming.
- 53. Reinhart, D.P. 1989. Effects of fire on cutthroat trout spawning streams and associated bear use. Pages 19-27 *in* Yellowstone grizzly bear investigations: annual report of the Interagency Grizzly Bear Study Team. U.S. Geological Survey, Bozeman, Montana.
- 54. Haroldson, M., D. Reinhart, K. Gunther, and L. Waits. 1998. Spawning cutthroat trout numbers on tributary streams to Yellowstone Lake. Pages 33-39 in Yellowstone grizzly bear investigations: Annual report of the Interagency Grizzly Bear Study Team. U.S. Geological Survey, Bozeman, Montana.

## References





- Amman, G.D., and K. C. Ryan, K. C. 1991. Insect infestation of fire-injured trees in the Greater Yellowstone Area. USDA Forest Service, Intermountain Research Station, Ogden, Utah. Research Note INT-398.
- Anderson, J.E., and W.H. Romme. 1991. Initial floristics in lodgepole pine forests following the 1988 Yellowstone fires. International Journal of Wildland Fire. 1:119-124.
- Balling, R.C., Meyer, G.A., and S.G. Wells. 1992a. Climate change in Yellowstone National Park: Is the drought-related risk of wildfires increasing? Climatic change 22:35-45.
- \_\_\_\_\_\_, and \_\_\_\_\_\_. 1992b. Relation of surface climate and burned area in Yellowstone National Park. Agricultural and Forest Meteorology. 60(3-4):285-293.
- Barmore, W. *In press.* Ecology of ungulates and their winter range in Yellowstone National Park. Yellowstone Center for Resources, Yellowstone National Park, Mammoth, Hot Springs, Wyoming.
- Barrett, S.W. 1994. Fire regimes on andesitic mountain terrain in northeastern Yellowstone National Park, Wyoming. International Journal of Wildland Fire 4(2):65-76.
- Bath, A.J. 1993. Attitudes toward fire and fire management issues in Yellowstone National Park. Dissertation, University of Calgary, Alberta, Canada.
- Beetle, D.E. 1997. Recolonization of burned aspen groves by land snails. Yellowstone Science 5(3):6-8.
- Bissonette, J.A. and S.S. Sherburne. 1992. Habitat preferences of unexploited pine marten (*Martes americana*) populations in Yellowstone National Park. Final report. Utah Cooperative Fish and Wildlife Research Unit, Logan, Utah.
- Blanchard, B.M., and R.R. Knight. 1990. Reactions of grizzly bears to wildfire in Yellowstone National Park. Canadian Field-Naturalist 104:592-594.
- Boltz, G., D.G. Carty, R.D. Jones, L.R. Kaeding, D.L. Mahony, and T. Olliff. 1993. Annual project technical report for 1992, fishery and aquatic management program, Yellowstone National Park. U.S. Fish and Wildlife Service, Yellowstone National Park. 171pages.

- Bonnicksen, T.M. 1989. Fire gods and federal policy. American Forests 95(7/8): 14-16.
- Brown, J.K. 1989. Could the 1988 fires in Yellowstone have been avoided through prescribed burning? Fire Management Notes 50(4): 7-13.
- Cannon, K.P., and P. Phillips. 1993. Post-fire inventory and evaluation in Yellowstone National Park: the 1989 field season. Midwest Archeological Center Technical Report No. 24.
- Chase, A. 1988. How Yellowstone got burned. Outside 13(12): 33, 35-36.
- Christensen, N.L., J.K. Agee, P.F. Brussard, J. Hughes, D.H. Knight, G.W. Minshall, J.M. Peek, S.J. Pyne, F.J. Swanson, J.W. Thomas, S. Wells, S.E. Williams, and H.A. Wright. 1989. Ecological consequences of the 1988 fires in the Greater Yellowstone Area. The Greater Yellowstone Postfire Ecological Assessment Workshop Final Report. 58 pages.
- Christiansen, T. 1996. Terrestrial litter invertebrate communities in Yellowstone Park. Yellowstone Science. 4(2): 2-3.
- Comstock, Theo. B. 1874. The Yellowstone National Park: its scientific value. American Naturalist. 8: 65-79
- Connor, M.A., and K.P. Cannon. 1991. Forest fires as a site formation process in the Rocky Mountains of northwestern Wyoming. Archaeology in Montana. 32(2):1-14.
- \_\_\_\_\_\_, and D. Carlevato. 1989. The mountain burnt: forest fires and site formation processes. North American Archaeologist. 10: 293-310.
- Crabtree, R.L. and J.W. Sheldon. 1999. The ecological role of coyotes on Yellowstone's northern range. Yellowstone Science 7(2):15-23.
- \_\_\_\_\_\_, and \_\_\_\_\_\_. 1994. Effects of 1988 fires on ecology of coyotes in Yellowstone National Park. Pages 105-113 *in* The University of Wyoming National Park Service Research Center Annual Report
- Despain, D. 1990. Yellowstone vegetation, consequences of environment and history in a natural setting. Roberts Rinehart, Boulder, Colorado. 237 pages.
- \_\_\_\_\_, ed. 1994. Plants and their environments: proceed-

- ings of the first scientific conference on the Greater Yellowstone Ecosystem. Technical Report NPS/NRYELL/NRTR. USDI, NPS, Denver, Colorado.
- \_\_\_\_\_\_, A.R. Rodman, P. Schullery, and H.F. Shovic, H.F. 1989. Burned area survey of Yellowstone National Park: the fires of 1988. Division of Research and Geographic Information Systems Laboratory, Yellowstone National Park. 14 pages.
- Engstrom, D.R., C. Whitlock, S.C. Fritz, and H.E. Wright, Jr. 1991. Recent environmental changes inferred from the sediments of small lakes in Yellowstone's northern range. Journal of Paleolimnology 5(2):139-174.
- Ewing, R. 1996. Postfire suspended sediment from Yellowstone National Park, Wyoming. Journal of the American Water Resources Association 32(3):605-627.
- Farnes, P.E, W.W. McCaughey, and K.J. Hansen. *In press*. Role of fire in determining annual water yield in mountain watersheds. Chapter 11 *in* L. Wallace, ed. After the fires: the ecology of change in Yellowstone National Park. Yale University Press, New Haven, Connecticut.
- Fire Management Policy Review Team. 1989. Final report on fire management policy. U.S. Department of Interior, Fish and Wildlife Service, Washington, D.C.
- Gniadek, S. 1977. Some aspects of avian ecology following the 1974 Trail Creek and 1976 Divide fires in Yellowstone National Park. Final Research Report.
- Greenberg, M.R., D.B. Sachsman, P.M. Sandman, and K.L. Salomone. 1989. Risk, drama, and geography in coverage of environmental risk by network TV. Journalism Quarterly 66(2): 267-276.
- Greenlee, J M. 1996. Ecological implications of fire in Greater Yellowstone. Proceedings of the second biennial conference on the Greater Yellowstone Ecosystem, Yellowstone National Park, September 19-21, 1993. International Association of Wildland Fire, Fairfield, Washington. 235 pages.
- Gruell, G.E. 1980. Fire's influence on wildlife habitat on the Bridger-Teton National Forest, Wyoming. Intermountain Forest and Range Experiment Station. USDA Forest Service Research Paper INT-235.
- Haroldson, M., D. Reinhart, K. Gunther, and L. Waits. 1998. Spawning cutthroat trout numbers on tributary streams to Yellowstone Lake. Pages 33-39 *in* Yellowstone grizzly bear investigations: annual report of the

- Interagency Grizzly Bear Study Team. U.S. Geological Survey, Bozeman, Montana. 72 pages.
- Houston, D.B. 1982. The northern Yellowstone elk. MacMillan, New York. 474 pages.
- \_\_\_\_. 1983. Wildfires in Yellowstone National Park. Ecology 54(5): 1111-1117.
- Hutto, R.L. 1995. The composition of bird communities following stand-replacement fires in northern Rocky Mountain conifer forests. Conservation Biology. 9:1041-1058.
- Jakubas, W.J., R.A. Garrott, P.J. White, and D.R. Mertens. 1994. Fire-induced changes in the nutritional quality of lodgepole pine bark. Journal of Wildlife Management. 58:35-46.
- Johnson, A.M., S.W. Conner, and K.J. Feyl. 1991. Postfire identification of nineteenth century wooden structures. Archaeology in Montana. 32(2):33-47.
- Johnson, E.A., and G.I. Fryer. 1989. Population dynamics in lodgepole pine-Engelmann spruce forests. Ecology 70:1335-1345.
- Kay, C.E. 1993. Aspen seedlings in recently burned areas of Grand Teton and Yellowstone National Parks. Northwest Science 67(2):94-104.
- \_\_\_\_\_. 1997. Ungulate herbivory, willows, and political ecology in Yellowstone. Journal of Range Management 50(2):139-145.
- Keiter, R.B. and M. Boyce, eds. 1991. The Greater Yellowstone Ecosystem: redefining America's wilderness heritage. Yale University Press, New Haven, Connecticut.
- Kendall, K.C. 1998. Whitebark pine. Pages 483 to 485 in Mac, M.J., P.A. Opler, C.E. Puckette Haecker, and P.D. Doran, Status and trends of the nation's biological resources. Vol. 2. U.S. Department of the Interior, U.S. Geological Survey, Reston, Virginia.
- Knight, D.H. 1994. Mountains and plains: the ecology of Wyoming landscapes. Yale University Press, New Haven, Connecticut. 338 pages.
- \_\_\_\_\_, and L.L. Wallace. 1989. The Yellowstone fires: issues in landscape ecology. BioScience 39:707-715.
- Koch, E.D., and C.R. Peterson. 1995. Amphibians and reptiles of Yellowstone and Grand Teton National Park. University of Utah Press, Salt Lake City. 188 pages.

- Lathrop, R.G. 1994. Impacts of the 1988 wildfires on the water quality of Yellowstone and Lewis Lakes, Wyoming. International Journal of Wildland Fire 4(3):169-175.
- Lemke, T.O., J.A. Mack, and D.B. Houston. Winter range expansion by the northern Yellowstone elk herd. Intermountain Journal of Sciences 4(1/2): 1-9.
- Mahony, D.L., and R.E. Gresswell. 1998. Short-term postfire variation of physical habitat, fish populations, and associated aquatic communities in large streams of Yellowstone National Park. Conference abstract in Yellowstone Science supplement 6(2): 39.
- Marston, R.A., and D.H. Haire. 1990. Runoff and soil loss following the 1988 Yellowstone fires. Great Plains-Rocky Mountain Geographical Journal. 18:1-8.
- McEneaney, T. 1990. Yellowstone: not so black and white. The Living Bird Quarterly, Spring: 11-17.
- Meagher, M.M. and D. Houston. 1998. Yellowstone and the biology of time. University of Oklahoma Press, Norman, Oklahoma. 287 pages.
- Merrill, E., and R. Marrs. 1994. Remote sensing of vegetation recovery in grasslands after the 1988 fires in Yellowstone National Park. Pages 114-125 in The University of Wyoming National Park Service Research Center Annual Report.
- Meyer, G.A., and Wells, S.G. 1997. Fire-related sedimentation events on alluvial fans, Yellowstone National Park. Journal of Sedimentary Research. A67(5):776-791.
- Mihuc, T.B. and G.W. Minshall. 1995. Trophic generalists vs. trophic specialists: implications for food web dynamics in post-fire streams. Ecology 76:2361-2372.
- Mills, S., ed. 1989. The Greater Yellowstone postfire assessment. Greater Yellowstone Coordinating Committee. 147 pages.
- Millspaugh, S.H., C. Whitlock, and P. Bartlein. 2000. Variations in fire frequency and climate over the past 17,000 yr in central Yellowstone National Park. Geology (28)3:211-214.
- Minshall, G.W., J.T. Brock, and J.D. Varley. 1989. Wildfires and Yellowstone's stream ecosystems. BioScience 39:707-715.
- \_\_\_\_\_, and T.V. Royer. 1998. Stream ecosystem responses to the 1988 wildfires. Yellowstone Science 6(3):15-22.

- \_\_\_\_\_, and C.T. Robinson. 1993. Effects of the 1988 wildfires on stream systems of Yellowstone National Park: five year comparison. Final report, University of Wyoming/National Park Service research center.
- Benthic community structure in two adjacent streams in Yellowstone National Park five years after the 1988 wildfires. Great Basin Naturalist 55(3):193-200.
- Montagne, C., and E. Skogley. 1992. Burned-unburned resin extractor soil nutrient comparison. Final report from the Plant and Soil Science Department and the Montana Agricultural Experiment Station, Montana State University, Bozeman, Montana.
- Morrison, M. 1993. Fire in paradise: the Yellowstone fires and the politics of environmentalism, HarperCollins Publishers, Inc., New York.
- Neckels, J., B. Mutch, R. Wallace, B. Van Zee, and E. Waldapfel. 1988. Greater Yellowstone Area fire situation1988. Greater Yellowstone Coordinating Committee. Billings, Montana.
- Nyland, R.D. 1998. Patterns of lodgepole pine regeneration following the 1988 Yellowstone fires. Forest Ecology and Management 111(1): 23-33.
- Parker, D.L. and L.E. Stipe. 1993. A sequence of destruction: mountain pine beetle and wildfire. Technical Report, USDA Forest Service, Southwestern Region.
- Pearson, S., M.G. Turner, L.L. Wallace, and W.H. Romme. 1995. Winter habitat use by large ungulates following fire in northern Yellowstone National Park. Ecological Applications 5(3):744-755.
- Podruzny, S.R., D.P. Reinhart, amd D.J. Mattson. *In press.* Fire, red squirrels, whitebark pine and Yellowstone grizzly bears. Ecology.
- Polzin, P.E., M.S. Yuan, and E.G. Schuster. 1993. Some economic impacts of the 1988 fires in the Yellowstone area. U.S. Department of Agriculture, Forest Service. Research Note INT-418.
- Pyne, S.J. [1982] 1997. Fire in America, a cultural history of wildland and rural fire. Reprint by University of Washington Press.
- Pyne, S.J. 1989. Letting wild fire loose: the fires of '88. Montana, The Magazine of Western Living 39(3):76-79.
- Reed, R.A., M.E Finley, W.H. Romme, and M.G. Turner.

- 1999. Aboveground net primary production and leafarea index in early postfire vegetation in Yellowstone National Park. Ecosystems 2:88-94.
- Reinhart, D.P. 1989. Effects of fire on cutthroat trout spawning streams and associated bear use. Pages 19-27 *in* Yellowstone grizzly bear investigations: annual report of the Interagency Grizzly Bear Study Team. U.S. Geological Survey, Bozeman, Montana.
- Renkin, R., and D. Despain. 1992. Fuel moisture, forest type, and lightning-caused fire in Yellowstone National Park. Canadian Journal of Forest Research 22(1):37-45.
- Ripple, W.J., and E.J. Larsen. *In press*. The role of postfire coarse woody debris in aspen regeneration. Western Journal of Applied Forestry 16(2).
- Roemhild, G. 1994. Aquatic insects and the fires of 1988. Yellowstone Science 2(2):2-4.
- Rolston, H. 1989. Biology and philosophy in Yellowstone. Biology and Philosophy 5(2): 241-258.
- Romme, W.H. 1982. Fire and landscape diversity in subalpine forests of Yellowstone National Park. Ecological Monographs. 52(2): 199-221.
- \_\_\_\_\_, and D.G. Despain. 1989. Historical perspective on the Yellowstone fires of 1988. BioScience. 39(10):695-699.
- \_\_\_\_\_, and D.H. Knight. 1982. Landscape diversity: the concept applied to Yellowstone Park. BioScience 32(8): 664-669.
- \_\_\_\_\_, M.G. Turner. R.H. Gardner, W.W. Hargrove, G.A. Tuskan, D.G. Despain, and R.A. Renkin. 1997. A rare episode of sexual reproduction in aspen (*Populus tremuloides Michx.*) following the 1988 Yellowstone fires. Natural Areas Journal. 17:17-25.
- \_\_\_\_\_, \_\_\_\_, L.L. Wallace, and J.S. Walker. 1995. Aspen, elk, and fire in northern Yellowstone National Park. Ecology 76(7):2097-2106.
- Rothermel, R.C., R.A. Hartford, and C.H. Chase. 1994. Fire growth maps for the 1988 Greater Yellowstone Area fires. USFS Technical Report INT-304. 64 pages.
- Runnells, D.D., and M.A. Siders. 1991. Impact of the 1988 forest fires on the chemistry of ground water in Yellowstone National Park. Pages 249-255 *in* University of Wyoming National Park Service Research Center Annual Report.

- Schullery, P., and D.G. Despain. 1989. Prescribed burning in Yellowstone National Park: a doubtful proposition. West. Wildlands 15(2):30-34.
- \_\_\_\_\_\_, and L. Whittlesey. 1992. The documentary record of wolves and related wildlife species in the Yellowstone National Park area prior to 1882. Pages 1-73 in J.D. Varley and W.G. Brewster, eds. Wolves for Yellowstone? A report to the U.S. Congress, Vol. 4. National Park Service, Yellowstone National Park, Wyoming.
- Sherburne, S.S. and Bissonette, J.A.. 1994. Marten subnivean access point use: response to subnivean prey levels. Journal of Wildlife Management 58(3): 400-405.
- Singer, F.J., ed. 1996. Effects of grazing by wild ungulates in Yellowstone National Park. National Park Service, Natural Resource Information Division, Denver, Colorado. 375 pages.
- \_\_\_\_\_, and M.K. Harter. 1996. Comparative effects of elk herbivory and 1988 fires on northern Yellowstone National Park grasslands. Ecological Applications 6(1): 185-199.
- \_\_\_\_\_, A. Harting, K.K. Symonds, and M.B. Coughenour. 1997. Density dependence, compensation, and environmental effects on elk calf mortality in Yellowstone National Park. Journal of Wildlife Management 61(1): 12-15.
- \_\_\_\_\_, L.C. Mack, and R.C. Cates. 1994. Ungulate herbivory of willows on Yellowstone's northern winter range. Journal of Range Management 47:435-443.
- \_\_\_\_\_, W. Schreier, J. Oppenheim, and E.O. Garton. 1989. Drought, fires, and large mammals. BioScience 39(10):716-722.
- \_\_\_\_\_, and P. Schullery. 1989. Yellowstone wildlife: populations in process. Western Wildlands 15(2):18-22.
- \_\_\_\_\_, Zeigenfuss, L.C., Cates, R.G., and D.T. Barnett, D.T. 1998. Elk, multiple factors, and persistence of willows in national parks. Wildlife Society Bulletin 26(3):419-428.
- Taylor, D.L. 1973. Some ecological implications of forest fire control in Yellowstone National Park. Ecology 54 (6):1394-1396.
- \_\_\_\_\_. 1982. Competition between mountain bluebirds and tree swallows in post-fire areas of Yellowstone National Park. National Geographic Society Research Reports 14: 655-667.

- Theriot, E.C., S.C. Fritz, and R.W. Gresswell. 1997. Longterm limnological data from the larger lakes of Yellowstone National Park. Arctic and Alpine Research 29(3): 304-314.
- Tinker, D.B., and D.H. Knight. 1998. Fire and the dynamics of coarse woody debris in Yellowstone National Park. Page 53 in Yellowstone Science supplement, agenda & abstracts 6(2):53.
- Tomback. D.F., ed. *In press*. Whitebark pine communities: ecology and restoration. Island Press, Washington, D.C.
- \_\_\_\_\_, D.F., A.J. Anderies, K.S. Carsey, and M.L. Powell. In press. Delayed seed germination in whitebark pine and regeneration patterns following the Yellowstone fires. Ecology.
- Tracy, B.F. 1997. Fire effects in Yellowstone's grasslands. Yellowstone Science 5(3): 2-5.
- \_\_\_\_\_. 1998 Fire effects, elk, and ecosystem resilience in Yellowstone's sagebrush grasslands. Conference abstract in Yellowstone Science supplement 6(2):53.
- \_\_\_\_\_, and S.J. McNaughton. 1997. Elk grazing and vegetation responses following a late season fire in Yellowstone National Park. Plant Ecology 130 (2):111-119.
- Turner, M.G., W. W. Hargrove, R.H. Gardner, and W. H. Romme. 1994a. Effects of fire on landscape heterogeneity in Yellowstone National Park. Journal of Vegetation Science 5:731-742.
- \_\_\_\_\_\_, R.A. Reed, W.H. Romme, M.E. Finley, and D.H. Knight. 1997. Above-ground net primary production, leaf area index, and nitrogen dynamics in early post-fire vegetation. Pages 130 to 134 *in* University of Wyoming National Park Service Research Center.
- \_\_\_\_\_, W.H. Romme, R.H. Gardner, and W.W. Hargrove. 1997. Effects of fire size and pattern on early succession in Yellowstone National Park. Ecological Monographs 76(4):411-433.
- \_\_\_\_\_, Y. Wu, L.L. Wallace, W.H. Romme, and A. Brenkert. 1994b. Simulating winter interactions among ungu-

- lates, vegetation, and fire in northern Yellowstone Park. Ecological Applications 4(3):472-496.
- Tyers, D.B. Submitted Ph.D. diss. Winter ecology of moose on the northern Yellowstone range. Montana State University, Bozeman.
- U.S. Fish and Wildlife Service. 1993. Annual project technical report for 1992, fishery and aquatic management program, Yellowstone National Park.
- Varley, J.D. and P. Schullery. 1991. Reality and opportunity in the Yellowstone fires of 1988. Pages 105-122 in R.B. Keiter and M. Boyce, eds. The Greater Yellowstone Ecosystem: redefining America's wilderness heritage. Yale University Press, New Haven, Connecticut.
- Varley, J.D. and P. Schullery. 2000. Yellowstone fishes: ecology, history, and angling in the park. Stackpole Books, Mechanicsburg, Pennsylvania.
- Wallace, L.L., M.G. Turner, W.H. Romme, R.V. O'Neill and Y. Wu. 1995. Scale of heterogeneity of forage production and winter foraging by elk and bison. Landscape Ecology. 10(2):75-83.
- White, C.A., C.E. Olmsted, and C.E. Kay. 1998. Aspen, elk, and fire in the Rocky Mountain national parks of North America. Wildlife Society Bulletin 26(3): 449-462.
- White, P.J., and R.A. Garrott. 1993. Bark eating by Yellowstone elk. Yellowstone Science 1(4):2-5.
- Williams, E.D., and S.C. Smith. 1990. Rehabilitation of fire suppression impacts on the North Fork fire in Yellowstone National Park. Report to the U.S. Department of the Interior. YNP/LA 90-01.
- Wu, Y., M.G. Turner, L.L. Wallace, and W.H. Romme. 1996. Elk survival following the 1988 fires: a simulation experiment. Natural Areas Journal 16(3):198-207.
- Yellowstone National Park. 1997. Yellowstone's northern range: complexity and change in a wildland ecosytem. National Park Service, Mammoth Hot Springs, Wyoming. 148 pages.



economic impacts, 3, 26, 40-41, 43

elk, 3, 5, 33, 48, 58-62, 65-67, 69-75

Engelmann spruce, 13, 14, 47-49, 57

## Index



Absaroka-Beartooth Wilderness, 23, 77 erosion, 47, 86-93 aircraft, 19, 20, 23-26 exotic plants, 3, 5, 68 air quality, 25 explosives, 23 algae, 94-96 Falls fire, 22 alluvial fans, 8-9, 87 Fan Creek, 93 American Indians, 38-39 Fan fire, 27 amphibians, 85 fire behavior, 14-16, 17-21, 23-26, 43 Amphitheater Creek, 94 fire frequency, 5, 7-14, 17, 21, 46 fire management policy, 4, 8-11, 15-16, 20-21, 29-30, andesitic soil, 50 43-45 archeological sites, 38-39 aspen, 5, 48-50, 58-62, 84 fire perimeter, 18, 19, 27 bald eagles, 3, 70, 71, 82 fire retardants, 23, 26, 37, 93 bark beetles, 53-54 fire suppression impacts, 35-37, 48, 58, 66, 68, 80, 93 Baronett Cabin, 39 fire suppression policy, 10-11, 15, 20-21, 43, 45 backfires, 23, 25, 74 firefighting, 2, 4, 10-11, 20-26 bears, 3, 5, 69, 71, 78-79, 99 Firehole River, 61, 93, 97, 98 beaver, 58, 67 fireline, 23-24, 35-37 beetles, 53-54, 83 fish, 5, 93, 98-99 biodiversity, 51, 52 flooding, 5, 86, 88 birds, 2, 50, 51, 57, 70, 81-83 forage quality, 70-77 bison, 69-71 forbs, 72-73, 75, 90 Black Saturday, 19, 29 fuel loads, 14, 20-21, 23, 44 Blacktail Deer Creek, 93, 98 fuel moisture, 8, 13-14, 18, 23 Blacktail Plateau, 73 gateway communities, 3, 24-26, 41, 43 blister rust, 57 Gallatin National Forest, 22, 27, 46, 57, 76, 88 Boise Interagency Fire Center, 24, 44 Gardiner, 25 Bridger-Teton National Forest, 27 Gardner River, 98 bulldozers, 4, 23, 35, 36 Gibbon River, 24, 86, 87, 94, 97, 98 Cache Creek, 87, 94, 96, 98 Glacier National Park, 31 Canyon Village, 24, 40 Grand Teton National Park, 32, 57, 95 carrying capacity, 71 Grant Village, 22, 25, 40 Clark's nutcracker, 57, 82, 83 grasslands, 8, 10, 15, 20, 47, 48, 50, 64-65, 73-75, 84 climate, 9, 14, 17, 47-48, 54, 57, 62, 67 Greater Yellowstone Coordinating Committee, 32 Clover Mist fire, 27, 89 Heart Lake, 8, 95 Cooke City, 25 helicopters, 20, 23, 24, 26, 37 coyotes, 71, 80 Hellroaring Creek, 98 Crow Creek, 88-89, 92 Hellroaring fire, 21, 27 Custer National Forest, 27, 74 herbaceous plants, 47, 63-66, 68, 74, 84 Huck fire, 27 cutthroat trout, 78, 98-99 hunting outside the park, 71, 76, 77 decomposition, 7 deer, 70, 71 insects, 53-54, 81-84, 92, 996-97 diatoms, 93, 94-95 invertebrates, 84, 93 Douglas-fir, 8, 14, 47-49, 53-54 Iron Springs Creek, 93

Jackson Hole, 58, 76

Jones Creek, 88-89, 92, 98

Jackson Lake, 95

lakes, 95 runoff, 86-93 Lamar River, 50, 75, 89, 91, 97, 98 sagebrush, 47, 48, 50, 64-65, 66, 72-73 Lamar Valley, 48 sedges, 65, 74 Lewis Lake, 22, 95 sediment deposits, 86-87, 90-92, 95 lightning, 1, 4, 7, 11, 15, 17, 22, 44 seed source, 35, 46, 50-52, 55, 57, 63 lodgepole pine, 2, 5, 8, 11-14, 16, 47-49, 52-56, 63, 74, serotinous cones, 55-56 Shoshone Lake, 95 Shoshone National Forest, 25, 27, 46, 51, 89, 98 logging, 26, 52, 80, 81, 89 macroinvertebrates, 92, 96-97, 99 Shoshone River, 98 Silver Gate, 25 Madison Junction, 24 Madison River, 31, 37, 61, 88, 92, 94 Slough Creek. 97 Mammoth Hot Springs, 25, 31, 40 Smokey Bear, 1, 28 marten, 80-81 snails, 84 meadows, 48, 64-65 snowpack, 86-91 Snake River, 92 media coverage, 28-31 Medicine Bow National Forest, 90 Snake River fire, 27, 37 military assistance, 24, 26 Soda Butte Creek, 89, 93 Mink fire, 27 soils, 35-37, 38, 47, 49-51, 63 moose, 2, 5, 66, 70 Sportsman Lake cabin, 34 mortalities, human, 2, 25 squirrels, 77-78, 80 mortality, wildlife, 69-71, 73, 78 Storm Creek fire, 22, 27 Mount Washburn, 51, 57, 78 subalpine fir, 13, 14, 47-49, 57, 76-77 National Park Service, 10-11, 19, 20, 22, 28-30, 32-33, Targhee National Forest, 22, 27, 36, 46, 53 35, 42-44 tree mortality, 52-54 nitrates, 94 tourism, 3, 28, 40-42 Norris Geyser Basin, 24 tree rings, 8-9, 47 North Fork fire, 21-24, 26, 31, 36, 74 U.S. Fish and Wildlife Service, 89 northern range, 6, 8, 10, 14-15, 20, 48, 58-62, 73-74, 80 U.S. Forest Service, 11, 19, 20, 26, 27, 28, 32, 35 nutrients, 7, 47, 72-74, 86, 92, 93 Virginia Cascades, 51 Obsidian Cliff, 38-39 visitation, 3, 5 Old Faithful, 1, 24, 25, 31, 34, 40 voles, 80 osprey, 2, 82, 83 water quality, 93-94 Pitchstone Plateau, 44 weather, 8, 14, 18, 25, 44 plant succession, 8, 13 West Thumb, 22, 99 prescribed burns, 4, 5, 15-16, 44-45, 74 West Yellowstone, 24, 25 pronghorn, 75 whitebark pine, 57, 77-78 public attitudes toward fire, 2-5, 10, 24, 28-31, 40-43 wildfire, 15, 43 rehabilitation, 34-37, 39 willows, 3, 5, 48, 66-67, 76-77 rhyolitic soil, 50, 94 woody debris, 86, 90-93 riparian vegetation, 89-90, 92, 93 wolves, 58, 59, 77, 80, 85 Rockefeller Memorial Parkway, 27, 53, 89 woodpeckers, 81-83 Rocky Mountain National Park, 67 Yellowstone Lake, 6, 88, 95, 98-99 Rose Creek, 94 Yellowstone River, 23, 39, 48, 50, 75, 91-93, 98